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BOLETES FROM SARAWAK

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ABSTRACT. Sixteen boletes (Basidiomycetes) are recorded from Sarawak in the following genera: *Aureoboletus, Austroboletus, Boletellus, Boletus* (including *Xerocomus*), *Heimiella, Pulveroboletus, Rubinoboletus, Setogyroporus, Strobilomyces* and *Tylopilus*. Two new combinations are made: *Boletellus fallax* (Corner) Watling and *Pulveroboletus icterinus* (Pat. & Baker) Watling. Records of *Pulveroboletus icterinus* are noted in passing. In an appendix *Boletus* subgenus *Punctispora* is transferred to *Heimiella* and the following new combinations are made: *Heimiella punctispora* (Corner) Watling; *H. betula* (Schw.) Watling; *H. alveolata* (Heim & Perreau) Watling; *H. fruticicola* (Berk.) Watling; and *H. ivoryi* (Singer) Watling.

INTRODUCTION

During the examination of agaric and bolete material collected by the Royal Geographical Society Expedition to the Gunong Mulu National Park, Sarawak in 1978, attention was also paid to material collected in Sarawak by P. J. B. Woods some eighteen years earlier. During the 1960s many of the specimens in the latter collection were of unfamiliar species and before determinations could be made it was necessary to wait the then expected monograph of Malaysian boletes by Corner (1972), itself a milestone in mycology. All the information on these SE Asian boletes has been brought together and comparisons are made with earlier collections and with recent Australian material collected by the senior author. Woods's material was included in collections of a general botanical nature, and was not from any particular habitat or vegetational community as indicated by the lignicolous fungi accompanying the boletes viz. *Heteroporus* aff. *biennis* (Bull.: Fries) Laz. (Polyporaceae), *Amauroderma rugosum* (Bl. & Nees) Torrend and *Ganoderma chalceum* (Cooke) Steyaert (Ganodermataceae), *Lentinus tenebrosus* (Corner) Pegler (Pleurotaceae), *Podoscypha involuta* (Klotszch apud Fries) Imazeki (Stereaceae), *Cookeina tricholoma* (Mont.) O. Kuntze (Sarcoscyphaceae) and *Xylaria tabacina* (Kickx) Fr. (= *X. telfairii* Berk.: Xylariaceae).

Corner (1972, 1974) recorded 24 boletes from this part of the world, five of which are recorded in the present study; eight additional taxa are considered below bringing the total to 35.

Using Corner's delimitation the present flora can be divided into *Aureoboletus* (1), *Austroboletus* (4), *Boletellus* (3), *Boletus* s. str. (4), *Heimiella* (3), *Leccinum* (1), *Pulveroboletus* (1), *Punctispora* (2), *Strobilomyces* (2), *Tylopilus* (8), and *Xerocomus* (5). The four unnamed taxa included in this survey are described as fully as possible for the benefit of future workers.

The genera are arranged alphabetically avoiding the necessity to define families as the authors feel that there is still much discussion required on this topic. The genera outlined by Pegler & Young (1981) have been adopted although the separation of *Xerocomus* from *Boletus* is uncertain (Watling, 1970). In the present study, although it was possible to distinguish the phylloporoid and boletoid hymenophoral tramas, it was impossible to distinguish the two genera satisfactorily because of lack of field data, especially spore-print colour. Although *Boletus* and *Xerocomus* are easily distinguished on the

'classic' species, they are impossible to define when extra-European taxa are considered.

Aureoboletus Pouzar.

A. thibetanus (Pat.) Hongo & Nagasawa in Rep. Tottori Mycol. Inst. 18: 133 (1980).

Syn.: ? *Boletus flexipes* Mass. in *Kew Bull.* 24: 208 (1909).

SARAWAK. 1st Division: Miri, Lambir Hills, growing in dry forest of dipterocarps and *Dryobalanops* sp., 'Cap (0.7, 1.5–), 1.7(2.1)" diameter, scarlet (dark blood red) shading darker above when young, surface slightly sticky; lower surface [pores] when young pale apricot becoming fawn to darker brown, stipe yellowish just below cap and sometimes at base, greater part crimson shading darker often in indistinct lines or patches and often overlying a paler yellowish red. When sectioned longitudinally, the cap is pale cream yellow, the stipe also but usually pinkish, the area around the junction of stipe and cap stains blue (the cap stained slightly but not always obviously)', 9 vii 1962, *Woods* 14 accompanied by colour transparencies (E).

The supporting microscopic data for *Woods* 14 are as follows: *Basidiospores* 10.5–11.5 × 4.5–5.5μm, subfusoid, smooth, pale tawny to honey-coloured in ammonia. *Basidia* 4-spored, 17.5–19 × 7–8μm, clavate-pedicellate, hyaline or pale honey-coloured. *Pleurocystidia* rare, hyaline, ampulliform, 32–35 × 9–10μm with narrow neck ⩽ 7.5μm long; *cheilocystidia* similar, forming sterile edge, either elongate clavate with slight constriction at apex or ampulliform and then 30–35μm long. *Hymenophoral trama* slightly bilateral with hyaline, slightly gelatinized, ill-defined lateral strata divergent from similarly coloured mediostratum. *Pileipellis* an irregular, highly gelatinized cutis with widely dispersed, and ± disintegrating, hyaline or honey-coloured, twisted hyphal units 5–8μm broad with smooth or irregularly roughened walls from pigment deposits and amorphous material in gel and with end-cells slightly or undifferentiated and at most shortly and slightly torpedo-shaped; *mediopellis* well demarcated, more compacted and orange tawny with hyphae 2.5–5.5μm broad seated on subpellis of similar but more loosely arranged, hyaline or honey-coloured elements. *Pileus trama* hyaline, floccose, open, ⩽ 10μm broad, compacted immediately above the tubes to form a honey-coloured zone. *Clamp-connections* not seen.

This collection could possibly be associated with the dipterocarps which are known to be ectomycorrhizal. Originally described from Tibet by Patouillard (1895), *Boletus thibetanus* is now known from Yunnan (Chui, 1948), Singapore (Corner, 1972) and Sarawak (Corner, 1974), although dipterocarps are not known in the first two localities. Singer (1986) places this species in *Pulveroboletus* (q.v.).

Corner (1972) believed *Boletus flexipes* Massee, also described from Singapore, to be the same fungus. This is probably so but no type material exists in K for comparison and only an illustration by Ridley remains. The pileus is much browner than *Woods* 14 although in other respects the collections agree. For completeness Massee's description (1909: 208) is provided:

Boletus flexipes, Massee.

Pileus tenuis, e convexo planus, interdum centro depressus, glaber, castaneus, zona lata umbrina in medio pilei ornatus, 4–5 cm. latus. *Tubuli* in stipite subdecurrentes, curti, flavescentes; pori rotundati, minutissimi, aurei. *Stipes* solidus, flexuosus, sursum attenuatus,

pallidus vel tinctura leviter rubescente-flavida praeditus, 6 cm. longus, 6–8 mm. latus. *Sporae* oblongo-fuscideae, interdum curvulae, 7–9 × 5 μm. *Caro* 3–4 mm. crassa, compacta.

Massee described this as 'A very beautiful species readily recognised by the plain chestnut coloured-pileus, golden pores and pallid, flexuous stem'. He also considered there was an affinity with the European *Boletus vaccinus* Fr. now considered by modern authors to be the same as *B. badius* Fr. or at least clearly related to it. *Woods* 14 is distinctly tinged vinaceous but this is considered meantime to come within the limits of *B. thibetanus*, although future work may show that a second species is involved.

Austroboletus Wolfe

A. dictyotus (Boedijn) Wolfe in Bibl. Mycol. 69: 92 (1979).

SARAWAK. 10th Division: Sammangoh Forest Reserve, growing at base of *Cyrtandra* sp., 'Cap glutinous? whitish/fawn, convex with acute umbo. Pores pale whitish mauve. Stipe cream-white with long raised reticulations, glutinous', 13 viii 1962, *Woods* 17 (E).

This is clearly related to *Boletus mucosus* Corner (1972) which is recorded, usually in troops, in deep humus in the forests of Singapore. *A dictyotus* differs by lacking a ring. However, it is of interest to note that, although not recorded previously, the surface of the stipe can become glutinous; this indicates in parallel to *B. mucosus* a relationship between the pileipellis and stipitipellis. Horak (1980) has shown that *B. mucosus* is in fact the same as *Austroboletus rostrupii* (H. & P. Sydow) Horak (syn.: *Boletus lacunosus* Rostrup, 1902 not *B. lacunosus* Cooke & Massee, 1889), which is now known from Sarawak, Singapore and Thailand.

A. dictyotus is said to be uncommon in SE Asia, and when it is found it is very variable. Corner (1972) consequently admits five varieties based on spore-morphology and spore-size. All the collections Corner has made although similar macroscopically, differ in spore details which is a little alarming as spore morphology is rarely as variable in other boletes with ornamented spores (see Wolfe, 1979). Corner's varieties are based on single collections and are recorded from Singapore (var. *cristatosporus*, spores cristate-verrucose, 16–21 × 7–11μm), Borneo (var. *kinabulensis*, spores reticulate, 17–19 × 8.5–9μm), Malaya and Sarawak (var. *morchellipes*, spores verrucose, 13–15 × 5.5–6.5μm), and Malaya (var. *verrucisporus*, spores verrucose, 15–17 × 8–9μm). The type variety with spores 11–16 × 6–8μm is recorded from Singapore and is based on Boedijn's (1960) original accounts from Java; our material extends the range of the type variety to Sarawak.

The spores in *Woods* 17 are amygdaliform with strong ornamentation about the middle, smooth at the extreme ends and measure 12.8–14 × 6.4–7.4μm (Figs 1 & 2).

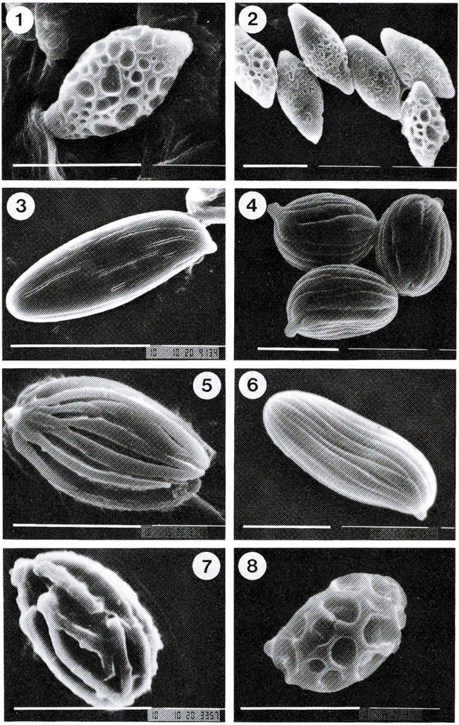
The occurrence with *Cyrtandra* (Gesneriaceae) of *Woods* 17 is not considered significant.

Boletellus Murrill

cf. **B. fallax** (Corner) Watling, **comb. nov.**

Basionym: *Boletus fallax* Corner, Boletus in Malaysia 99 (1972).

SARAWAK. 1st Division: Bako National Park, Tanjong Sapi, 'Cap and stipe fawn', 18 iv 1962, *Woods* 2 (E).



FIGS 1–8. Scanning electron micrographs of basidiospores*.
FIGS 1 & 2, *Austroboletus dictyotus* (*Woods* 17); FIG. 3, *Boletellus obscureococcineus* (BRIP 9134); FIG. 4, *Boletellus longicollis* (*Woods* 21); FIG. 5, *Boletellus russellii* (*Watling* 5178); FIG. 6, *Boletellus emodensis* (BRIP 9137); FIG. 7, *Afroboletus* sp. (*Ivory* 335/7); FIG. 8, *Heimiella retispora* (*Woods* 11). Scale bars (l.h.) = 10μm.

*All material was rehydrated with 10% ammonium hydroxide and A coated for 2 mins at 20mA.

The material is accompanied by a water colour sketch which provides the following additional information:
Pileus 20mm broad with creamy white flesh. *Stipe* 40 × 4mm with whitish flesh at apex tinged with pale fawn towards base; unchanging. *Tubes* pale yellow (luteous), unchanging; *pores* concolorous, somewhat reticulate.

Unfortunately the collection is almost sterile but the few basidiospores present are longitudinally and finely striate as in the *Boletellus obscurecoccineus* (Hoehn.) Singer group (Fig. 3) and measure 16.5 × 5.5μm; further reference should be made to Watling & Gregory (1986) where the complex is treated in greater detail. This collection differs from Corner's *B. fallax* in lacking rose-red colours.

Boletellus fallax was described by Corner (as *Boletus*, 1972) from Pahang, Negri Sembilan and Singapore (Bukit Tumah). Corner (1972) also makes reference to *Boletellus pustulatus* (Beeli) Gilbert and *B. longipes* Heinem. both from Central Africa, and to *B. purpurascens* Heinem. which has verrucose spores and is an *Austroboletus*.

The structure of the hymenophore is intermediate with that of several species placed in the genus *Phylloporus* and once again shows the relatively close relationship between boletes and those agarics the senior author assigns to the Paxillaceae (Watling, 1970).

B. longicollis (Ces.) Pegler & Young in Trans. Brit. Mycol. Soc. 76: 115 (1981). SARAWAK. 1st Division: Poch Range, Berumpet, 1097m., 'Cap 2″ diam., light reddish brown, glutinous above, yellowish below [pores]. Stipe 7″ long with a yellowish white veil or collar; stipe whitish (± mealy) on fawn, + fawn-coloured striations near the base. Spore print brown', 12 viii 1962, *Woods* 21 (E).

This is a fascinating and very elegant fungus but unfortunately the material is poorly preserved, although the tall, slender stipe with a peculiar texture is plainly obvious. *B. longicollis* is the type of sect. *Ixocephali* Singer in which its author includes *Boletellus jalapensis* (Murr.) Singer described from Mexico; this differs considerably, however, in the much larger basidiospores and lack of veil. *B. longicollis* is recorded from Malaya and Sarawak by Corner (1972: 74). Corner discusses the synonyms in detail; it was placed by Patouillard & Baker (1918) in their expanded concept of the genus *Boletopsis* Henn.

The basidiospores of *Woods* 21 are ovoid to broadly ellipsoid, costate, pale olivaceous brown with 15 or more deep, longitudinal furrows, sometimes joining at the apex to give the impression of a germ-pore (Fig. 4). They are ornamented in a similar way to those of *Boletellus russellii* (Frost) Gilbert (Fig. 5) and members of the *B. emodensis* complex (Fig. 6) (see Watling & Gregory, 1986), although there is also a distant similarity to members of the genus *Afroboletus* Pegler & Young (Fig. 7).

Boletus Fries
c.f. **B. peltatus** Corner, Boletus in Malaysia 136 (1972) nom. nudum (Art. 37). SARAWAK. 1st Division: Matang, on low bank amongst roots almost at the foot of the mountain, 18', 'Cap dark brown fading paler towards the edge; lower surface [pores] yellowish to yellowish-brown; flesh beneath pores a dark yellow towards the top, with reticulations', 15 vii 1962, *Woods* 18 (E).

Basidiospores 10.5–13 × 3.7–4.2μm, boletoid, reddish honey-coloured in ammonia, smooth. *Basidia* 4-spored, 12.5–14.75 × 4.75–5.25μm with sterigmata ⩽ 1.5μm. *Pleurocystidia* very rare, only observed in smaller tubes, fusiform lanceolate, hyaline, 36.75–50 × 5.25μm; *cheilocystidia* replaced by clavate cells, 18.25 × 7–8μm. *Pileipellis* an irregular tangle of hyaline, thin-walled, flexuous, septate hyphae with little or no apical differentiation but some slightly suberect, 2.6–5.25μm broad, collapsing to form small irregularities and then slightly agglutinated and pale honey-colour; *suprapellis* open, compacted downwards to form a relatively thick subpellis seated on the open similarly coloured context which becomes compacted and gelatinized above the tubes. *Hymenophoral trama* poorly differentiated and not strongly divergent, pale honey-coloured throughout, gelatinized. *Clamp connections* absent.

This collection from Serapi (= Matang) has basidiospores that agreed with Corner's description of his original material of *B. peltatus* from Johore (30 iii 1930, *Corner* s.n.). Unfortunately, the latter was lost during the war and comparative studies cannot be made; adequate collections are required in order for *B. peltatus* to be validated in accordance with Article 37.

Woods 18 further agrees in the overall brown coloration but the pores are possibly more yellow (greyish yellow in the Johore collection) and the stipe more definitely ornamented (lacunose-reticulate in the Johore collection). Corner (1972) drew attention to a similarity with *Boletus frostii* Russell which certainly has a distinctive red, strongly lacunose-alveolate to lacerate-reticulate stipe, but the overall colour of this N American bolete is dark red and not brown. The flesh in *B. frostii* is also strongly cyanescent when exposed to the atmosphere and the pileipellis is an ixotrichoderm. Unlike that taxon, Corner's fungus possesses a dry pileus and greyish olive (not red) pores.

Heimiella Boedijn

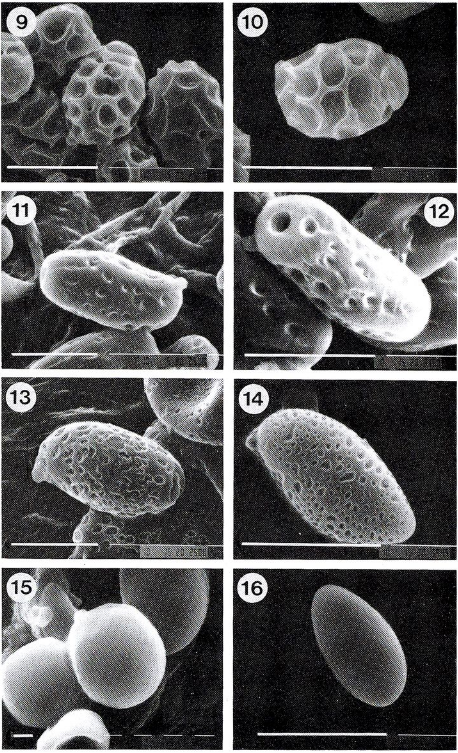
H. retispora (Pat. & Bak.) Boedijn in Sydowia 5: 217 (1951).

Syn.: *Boletus ridleyi* Massee in *Kew Bull.* (1909) 207 (1909) non *B. ridleyii* Massee, 1901, fide Corner, 1972.

SARAWAK. 4th Division: Miri, Lambir Hills, on rotting bark of old stump occurring 1½–3ft from ground, 'Cap velutinous (same as No. 10?) mauve purple becoming paler (powdery texture) and becoming finely mottled, gills [pores] at first same colour on yellow giving reddish tinge, becoming pale pinkish-mauve on yellow –1¾″ diam. Stipe yellow just below cap, when young very swollen at base and flask-like. Mauve-purple and darker often towards top 1⅓–2″ high,' 5 vii 1962, *Woods* 11 (E).

Being recorded from China to Malaysia this is apparently the most widespread member of the genus (Corner, 1972); it has also been recorded from Sarawak by Corner (1974), who indicates the habitat to be 'on the ground in forest generally gregarious, common in the lowlands and mountains to 1300m, often attached to buried wood'. This species is recognized by its alveolate ornamented basidiospores (Figs 8 & 9) and general colouring of the basidiomes.

The habit of the present collection of fruiting on wood above the ground is not apparently unusual in tropical to subtropical boletes: *Boletellus emodensis* (Berk.) Singer has been seen growing in Lamington National Park, Queensland on an old stringy bark (*Eucalyptus* sp.) and the phenomenon is recorded in *Heimiella* sp. 2 below. This growth probably allows the basidiome to release its



FIGS 9–16. Scanning electron micrographs of basidiospores. FIG. 9, *Heimiella retispora* (*Woods* 11); FIG. 10, *Heimiella* sp. 1 (*Woods* 10); FIGS 11 & 12, *Heimiella* sp. 2 (*Woods* 20); FIG. 13, *Heimiella betula* (*Thiers* 7186); FIG. 14, *Boletellus subflavidus* (BRIP 5945); FIG. 15, *Rubinoboletus* sp. (*Woods* 12); FIG. 16, *Setogyroporus* sp. (*Woods* 16). Scale bars (l.h.): 9–14, 16 = 10μm, 15 = 1μm.

spores into the turbulent atmosphere not found in the deep litter layer on the forest floor.

Heimiella sp. 1
SARAWAK. 4th Division, Miri, Lambir Hills, 'Stipe 15″ high, 1″ diameter at base, $\frac{3}{8}$″ diameter at top; cap 2(–2$\frac{1}{8}$)″ diam., 1$\frac{1}{8}$″ in depth, fawn mottled purplish brown, below pale yellow; stipe purplish brown slightly striate, base darkish brown growing on ground in humus. Spore print brown', 4 vii 1962, *Woods* 10 (E).

Unfortunately the pileus has been lost but the stipe and spores (from spore-print) are distinctive. It resembles *H. rubropunctata* Hongo (in Kobayasi *et al.*, 1973) from New Guinea in coloration but differs in its smaller basidiospores (11.1–12.2 × 7.7–8.8μm (Fig. 10) as opposed to 13–20 × 9–13μm) and purplish mottled pileus; the stipe is also much longer, in fact this fungus must be an impressive sight when seen in the field. Fresh collections of this spectacular new taxon are required for formal description.

Heimiella sp. 2
SARAWAK. 1st Division, Berumpet, 'Cap 3$\frac{1}{2}$″ diameter golden brown in colour fading towards margins. Surface rough or finely warted with larger, dark brown warts forming a reticulated pattern. Lower surface blackish yellow almost olive green; stipe—4″ long scarlet purple surface with narrow vertically running reticulations. Tree trunk 6′ from ground in Karungas. Spore print brown—olive brown', 16 viii 1962, *Woods* 20 (E).

The microscopic details of *Woods* 20 are as follows:
Basidiospores elongate-ellipsoid, strongly punctate with apical depression at hilar apex 15.75–19.5 × 8–10.5μm. *Basidia* 4-spored, 26.25 × 9.5μm clavate. *Pleurocystidia* and *cheilocystidia,* none revived. *Pileipellis* composed of tightly adhering, collapsed filamentous cells with only slight constrictions at the septa, slightly sausage-shaped, tawny honey contrasting with tissues below, end-cells rounded or torpedo-shaped, 12.5–15μm broad and walls yellowish honey, smooth or slightly asperulate, not gelatinized, compressed into irregular heaps of similar cells or mounds of swollen, inflated or ellipsoid cells, with a few laticiferous hyphae intermixed, 45 × 40μm, all seated on a radially arranged pellis of either twisted and contorted or flexuous filamentous hyphae, 6–7.5μm broad; *subpellis* composed only of flexuous hyphae, compacted and slightly gelatinized, passing into open context of floccose, hyaline anastomosing hyphae, c.7.8μm broad. *Hymenophoral trama* very narrow and very slightly divergent with lateral strata much reduced, at base of pileus trama becoming gelatinized, hyaline or only slightly coloured and passing into the darker coloured trama of broad, honey-coloured units.

The warted pileus and reticulate stipe are distinctive; in field characteristics this collection approaches *H. kinabaluensis* Corner. However, the basidiospores are quite unlike those of any of the boletes from Sarawak except the more recently described *Boletus punctisporus* Corner. Although similar in colour and general characters this latter species differs in its velar extension of the pileus which collapses at maturity as a ring on the stipe. No such ring is recorded by Woods and no evidence of its former presence can be located in his collection. At the basidiospore apex a depression is found within the pattern of ornamenta-

tion (Figs 11 & 12) and in this resembles the basidiospore of *Austroboletus betula* (Schw.) Horak (Fig. 13), but is quite unlike those of typical *Austroboletus* such as *A. subflavidus* (Murrill) Wolfe (Fig. 14), which are distinctly subfusiform (= boletoid) (see Appendix).

Pulveroboletus Murrill

P. icterinus (Pat. & Baker) Watling, **comb. nov.**

Basionym: *Boletopsis icterinus* Pat. & Baker in J. Straits Br. R. Asiatic Soc. 78: 68 (1918).

SARAWAK. 1st Division: Miri, Lambir Hills, growing on forest floor in leaf-litter, 'Cap 1½″ diameter mealy, lemon-yellow below same colour; stipe c.2″ long about ¼″ diam. at top, lemon-yellow, farinaceous, surface slightly rough', 7 vii 1962, *Woods* 13 (E); Matang, Gunong, 'Cap and stipe bright farinose yellow tinged very slightly lemon or lime', 29 v 1962, *Woods* 4 (E).

NEW GUINEA. Marobi District, Huon Peninsula, Rawlinson Mountains near Arigeenang Village, 22 vi 1968, *Woods, Black & Yakas* 2146.

The supporting microscopic data from *Woods* 13 are:

Basidiospores 7.75–10(–11) × 3.5–4.8µm, subfusoid-ellipsoid many without typical boletoid shape or with only a hint of that shape, honey-coloured in ammonia, more yellowish in Melzer's reagent. *Basidia* 16.5–22 × 5.5–7µm, yellowish in ammonia; hymenium distinctly yellow-brown in Melzer's solution. *Cheilocystidia* 25–36 × 5.5–7µm (4.2µm at apex), cylindrical lageniform, covered when immature in veil remnants; *pleurocystidia* rare, similar in colour. *Pileipellis* of interwoven, hyaline or, in ammonia only faintly coloured hyphae 3–8µm broad. *Hymenophoral trama* pale yellow in Melzer's reagent, slightly bilateral with central strand almost colourless and uniform with the lateral strata and not distinctly delimited from pileus trama. *Veil* a pulverulence passing gradually into more open pileipellis, pale yellow in Melzer's reagent and composed of hyaline to coloured, non-clamped hyphae 3–10µm broad, very variable in size and shape, encrusted or smooth, ± constricted at the septa and associated with a large amount of yellow amorphous detritus and many laticiferous elements ⩽ 50µm long although sometimes quite short, darker yellow in Melzer's reagent. In the primordia the cells immediately beneath the pulverulence are slightly more compacted although similarly coloured to the main pileus trama, often only 1.5–2µm broad but possibly forming an irregularly repent 'cuticle'. No fleeting amyloid reaction is found in the pileus trama.

All three collections agree in their characters and differ from *Pulveroboletus ravenelii* (Berk. & Curtis) Murrill, with which Corner (1972) synonimized *Boletopsis icterinus,* particularly in the size of the basidiomes and the vivid sulphur- or lime-yellow pulverulent pileus and stipe, as opposed to the lemon-chrome to orange yellow pulverulence in the N. American bolete. *P. ravenelii* is a much larger fungus reaching 10cm in diameter and has never been recorded with a pinkish buff or whitish mycelial fan from which the basidiomes arise as is seen in *Woods* 13.

Rubinoboletus Pilát & Dermek

Rubinoboletus sp.

SARAWAK. 1st Division, Miri, Lambir Hills, growing on forest floor in leaf litter, 'Cap 4½–5″ d., above mauve pink (powder-shade), roughly reticulated, the

raised roughened parts paler whitish; below [pores] pale creamy-yellow with very slightly pink tinge becoming darker and faintly brownish. Stipe pale yellow and flushed pink at top. The greater part pinkish-red with darker red striation, 3–4″ long $\frac{5}{8}$″ in diameter at top and to 2″ in diameter at base', 7 vii 1962, *Woods* 12 (E).

The coloured slides which accompany this material give an excellent indication of this bolete's stature, habit and habitat.

The roughly reticulate, mauve-pink stipe and pileus, pale yellow stipe-apex flushed with pink and pale creamy yellow pores, flushed pink and becoming brownish, are a distinct suite of characters. In the young stage the pileus is more or less rounded, very rough and pinkish seated on a yellow corm-like base.

The microscopic details are as follows:

Basidiospores 6.25–7.5 × 5.25–6μm (Fig. 15). *Basidia* 4-spored, 21 × 7.5–8μm clavate. *Hymenium* honey-coloured. No cystidia seen. *Pileipellis* composed of an epicutis of radially arranged, filamentous, not differentiated hyphae, collapsed onto a tawny layer of similar elements with a paler subpellis of slightly broader hyphae, 5.25–8μm broad, splitting medially; end-cells of the suprapellis suberect and capitate, 26.25–39.25 × 7.75–11.75μm. *Pileus trama* composed of hyaline, thin-walled hyphae above the tubes. *Hymenophoral trama* very narrow with a filamentous mediostratum and slightly divergent lateral strata.

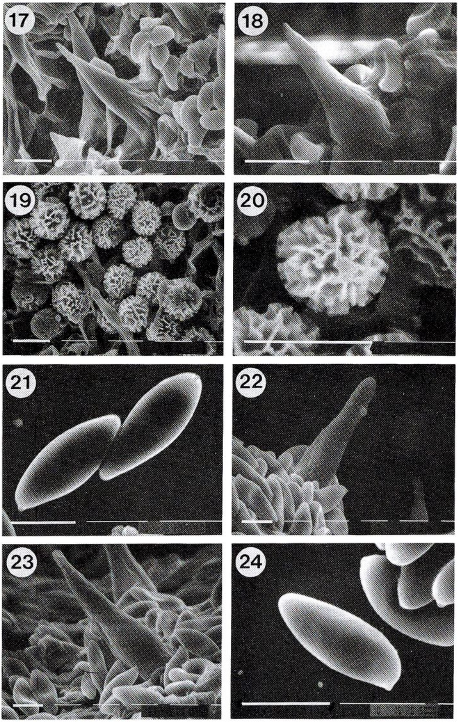
The placement of this collection is problematic but the red colours, small, pale, broadly ellipsoid basidiospores (Fig. 15) indicate a relationship with the *Boletus ballouii* complex, although the flesh of the latter is very tough and is not cyanescent. In *Tylopilus* where this bolete would be placed by Corner (1972) it would key out to *Boletus incertus* Corner and *B. cuticulatus* Corner but these both have larger, longer spores. It is apparently a new taxon blending together many of the characters found in both SE Asian and African tropical taxa.

Setogyroporus Heinemann & Rammeloo

Setogyroporus sp. cf. *Boletus mirans* Corner, Boletus in Malaysia 207 (1972). SARAWAK. 1st Division, Semangoh Forest Reserve, 'Cap brownish purple, almost liverish-coloured, smooth; stipe, purplish scarlet when sectioned, yellowish staining blue with a pithy scarlet core', 13 vii 1962, *Woods* 16 (E).

The supporting microscopic data for *Woods* 16 are:

Basidiospores 6.5 × 4.6μm, broadly oval to broadly ellipsoid, (Fig. 16) smooth, honey-coloured in ammonia. *Basidia* 4-spored, 21 × 10.5μm, hyaline or with yellowish colloidal material; sterigmata 2μm long. *Pleurocystidia* 34–60 × 10.75–13μm, prominent, lanceolate ventricose with acute apex, usually with a long pedicel, thick-walled especially towards centre and often with red-brown tips (Fig. 17); *cheilocystidia* similar although not as prominently thickened, nor as consistently red-brown in the apices (Fig. 18). *Pileipellis* a turf of narrow to slightly inflated hyphae, hyaline to pale honey-coloured, smooth or very slightly banded with slightly darker material, septate, disarticulating hyphae lacking clamp-connections and agglutinating in places to form orange-tawny frusta; end-cells of hyaline units, torpedo-shaped and 4–5.25μm broad, or slightly clavate and then ⩽ 7.75μm broad, and of pigmented hyphae (tawny coloured) similarly differentiated and 6.5–7.5μm broad; suprapellis seated on zone of orange-tawny hyphae giving rise to suberect units and passing into a paler compacted zone. *Pileus trama* composed of hyaline and anastomosing



FIGS 17–24. Scanning electron micrographs of basidiospores and cystidia. FIGS 17 & 18, *Setogyroporus* sp. (*Woods* 16), pleurocystidia, cheilocystidia; FIGS 19 & 20, *Strobilomyces velutipes* (*Woods* 15), basidiospores; FIGS 21–23, *Boletus* aff. *ascendens* (*Coppins* 5117), basidiospores, pleurocystidia, cheilocystidia; FIG. 24, *Boletus nugatorius* (*Woods* 6), basidiospores. Scale bars (l.h.) = 10μm.

hyphae 8–13μm broad, some slightly clavate and then ⩽ 7.75μm broad. *Hymenophoral trama* divergent with a broad, hyaline or slightly darker gelatinised mediostratum, and narrow, hyaline lateral strata from which cystidia emanate.

Because of the setiform cystidia (Figs 17 & 18) Corner (1972) places *B. mirans*, described from Malaya, in the subgenus *Xerocomus*. He compared it with *Boletus goossenii* Beeli, placed by Heinemann (1954) in *Boletochaete* and by Horak (1967) in *Tubiseta*, but this differs in the viscid pileus and slender red stipe and longer (boletoid) basidiospores. The present collection differs from *B. mirans* in the purple-scarlet (not yellow) stipe and scarlet pithy core to the cyanescent yellow stipe.

Tubiseta Horak is characterized by long basidiospores, thick-walled cystidia and boletoid hymenophoral trama, and *Boletochaete* has been retained for those boletes with ellipsoid basidiospores, phylloporoid hymenophoral trama, and cystidia with rigid walls, filled with oily or colloidal contents (Heinemann & Rammeloo, 1982). These same authors introduced the genus *Setogyroporus* (Heinemann & Rammeloo, 1982, 1983) for boletes with subglobose basidiospores and thick-walled cystidia. Corner (1972) has discussed and criticized this approach and reference should be made to *Tylopilus* sp. described below. The present collection would come within the circumscription of *Setogyroporus* until now known only from Morombo vegetation with *Brachystegia* in Central Africa.

Strobilomyces Berkeley

S. velutipes Cooke & Massee in Grevillea 18: 5 (1889).

SARAWAK. 1st Division, Semangoh Forest Reserve, 'Cap whitish grey with black scattered spots; below black; stipe greyish-black', 13 vii 1962, *Woods* 15 (E).

This collection has a very distinct basidiospore morphology of branched and unbranched ridges in a hyaline, winged membrane (Figs 19 & 20). This is characteristic of *S. velutipes* as described by Corner (1972) from Singapore where he made several collections, and also by Heinemann (1954) and Perreau-Betrand (1961, 1964) from collections made in Central Africa. Corner (1974) collected this species in the same general locality (Corner 1974: 159) as the present collection. The relationship of this species to *S. floccopus* (Vahl: Fr.) Karsten has been discussed by Watling & Gregory (1986) on recording *S. velutipes* from Victoria and Queensland (Australia).

Tylopilus Karsten

Boletus aff. **ascendens** Corner, Boletus in Malaysia 158 (1972).

SARAWAK. 4th Division, Baram District, Gonong Mulu National Park, c.2000m, on ground in shrub forest with *Rhododendron, Leptosperum*, '*Pileus* 60mm, plano-convex (15mm high), pale buff with yellow-green tinge. *Stipe* 50 × 10mm unornamented, yellowish buff, bright orange at base. *Tubes* pale buff, 10mm long. *Flesh* pale yellowish unchanging in pileus but on exposure slowly turning blue in lower part of stipe', 26 iv 1978, *Coppins* 5117 (E).

The supporting microscopic data for *Coppins* 5117 are:

Basidiospores 15–20 × 5.5–7μm, elongate subfusiform, (i.e. boletoid, see Fig. 21) only slightly coloured in water and ammonia. *Basidia* 4-spored,

11.75–13 × 18.25–21μm; sterigmata 2.6μm long. *Pleurocystidia* 52.5–60.25 × 10.75–19.5μm ventricose with prolonged subacute apex, distinctly thick-walled giving the entire structure a shiny, honey-yellow tinge (Figs. 22 & 23). *Pileipellis* collapsed on a radially arranged series of rounded, ellipsoid to subglobose, smooth cells, 21 × 15.75–18.25μm, ± filled with tawny vacuolar pigment and swollen towards end-cells giving a catenulate arrangement in a gelatinous matrix and seated on a mediopellis of open, filamentous, pale honey tawny hyphae 5.25–6.5μm broad, and a subpellis of filamentous, similarly or paler coloured, compacted hyphae; some filamentous cells with clavate ends push through the pileipellis. *Pileus trama* of open, hyaline, thin-walled, collapsing hyphae, 5–7.5μm broad. *Hymenophoral trama* of non-gelatinized, narrow, filamentous mediostratum with lateral strata hardly divergent but nevertheless accentuated by the thick-walled pleurocystidia.

The present collection is obviously related to the *Boletus olivaceoluteus* Corner-*B. ascendens* Corner complex (Corner, 1972) by virtue of the setiform pleurocystidia (Figs 22 & 23) differing from both in important characters. Thus *Coppins* 5117 possesses basidiospores with dimensions of similar magnitude to *B. ascendens* viz. 15–20 × 5.5–7μm as opposed to 17–25 × 5.7–7μm in *B. ascendens*, but lacks the dark colour and differs in the non-cyanescent flesh and dark fuscous umber pileus; the blueing in the Mulu collection is only in the stipe-base. From *B. olivaceoluteus* it differs in the much larger basidiospores (7–8.5 × 5–6μm in *B. olivaceoluteus*) and the rufous and minutely reddish furfuraceous stipe-apex. The Mulu collection had the bright orange stipe-base also seen in *B. ascendens* and the greenish tinge to the pileus recorded for *B. olivaceoluteus*. *B. ascendens* was apparently found in a similar community to the present collection.

B. ascendens has the thickened cystidia and is similar in spore-size to three species: *B. aculifer* Corner, *B. hastulifer* Corner and *B. setigerus* Corner, all described from SE Asia and placed in subgenus *Xerocomus* (Corner, 1972 & 1974); reference should also be made to *Boletochaete* discussed above. There appears to be a complex of taxa in tropical rain-forests possessing these thickened pleurocystidia; they are found in SE Asia and judging from the literature also in the African subcontinent (Heinemann, 1954 & 1966; Heinemann & Rammeloo, 1980 & 1983).

Xerocomus Quél

Boletus nugatorius Corner, Boletus in Malaysia 224 (1972)

SARAWAK. 1st Division, Santubong, 'Stipe smooth cream to creamy fawn, white when sectioned and not staining; lower surface of cap [pores] dirty yellowish cream to fawn; upper surface fawn to light brown sometimes creamy, sometimes concave, to 8 cm in diameter', 30 v 1962, *Woods* 6 (E).

Supporting microscope details from *Woods* 6 are as follows:

Basidiospores 10.5–16.75 × 4.75–6.25μm, typically boletoid, subfusiform, rich honey-yellow in ammonia (Fig. 24). *Basidia* 4-spored, 23.5 × 11.75μm; sterigmata 4μm. *Pleurocystidia* not seen. *Pileipellis* composed of a tangled mass of hyaline to pale honey-coloured, slightly gelatinized, richly branched and contorted hyphae, lacking clamp-connections, 2.5–4μm broad, collapsing to form a radially arranged structure and many constricted at the septa; *mediopellis* more open, of similar hyphae or with units ⩽ 9μm broad, uniformly honey-coloured or slightly darker in collapsed areas, passing into hyaline, thin-walled,

anastomosing hyphae of pileus-trama. *Hymenophoral trama* strongly filamentous, of non-gelatinised, hyaline or honey-coloured hyphae similar in both medio- and lateral strata and showing little divergence.

Corner (1972) described *B. nugatorius* as resembling a very small *B. subtomentosus* L.: Fr. but the pores are pallid ochraceous cinnamon and the resemblance is therefore only superficial. Later, Corner (1974) also referred a collection from Java (Tjibodas, 11 iv 1972, *Corner* J-6) to *B. nugatorius*. In the protologue, Corner (1972) indicates some relationship to *Xerocomus pseudotristes* Heinem. & Gooss. from Central Africa, with blackish stipe and pileus, and to *X. lentistipitatus* McNabb from New Zealand. However, the former has narrower basidiospores, 3.3–4.3μm as opposed to 4.5–5μm, and the latter wider pores, yellowish stipe-apex and flesh often becoming pinkish on cutting. The present collection differs only in its slightly paler pileus.

Boletus cf. **rectus** Corner

SARAWAK. 1st Division, Santubong, 'Stipe thick brown reticulate, rugose, lower surface of cap [pores] 'custard' yellow when young, becoming yellowish-brown, upper part of cap brown, slightly paler towards edge, with age becoming reddish-brown at edge, brown to blackish-brown towards the centre. Often concave; to 10cm diameter. Cap not staining when cut, the stipe, when cut, yellows a little', 30 v 1962, *Woods* 5 (E).

Supporting microscopic data for *Woods* 5 are:

Basidiospores 10.5–13 × 4.25–5.25μm, boletoid, rich honey-yellow in ammonia. *Basidia* 4-spored, 15.75 × 9.25–10.75μm; *sterigmata* ⩽ 1.25μm. *Pleurocystidia* 30–38 × 6.5–13μm, scattered but numerous, clustered to form a fringed sterile edge, hyaline, thin-walled, collapsing. *Pileipellis* quite prominent, open, composed of repent, collapsed, filamentous, non-gelatinized, honey-coloured hyphae, 4.5.25μm broad, lacking differentiated end-cells; *mediopellis* of broader units of similar but paler colour, ⩽ 13μm broad; *subpellis* of radially arranged, rather openly arranged, honey-coloured cells passing into a very open pileus-trama of thin-walled, collapsing cells. *Pileus-trama* half depth of pellis, neither strongly compacted nor gelatinized above the tubes. *Hymenophoral trama* with broad, non-gelatinized mediostratum and reduced filamentous, lateral strata; *hymenium* and base of tubes distinctly tawny yellow throughout.

This collection would be referred to subgenus *Xerocomus* as the hymenophoral trama is phylloporoid. The pileus is rather darker than indicated by Corner for *B. rectus* (blackish-brown as opposed to bay-chestnut) and becomes reddish-brown with age (as opposed to yellow-brown). The basidiospores measure 10.5–13.1 × 4.2–5.3μm, whereas those of Corner's fungus are 9.5–12.5 × 4.5–5.5μm. Corner compared his fungus with *B. pallidus* Frost, *B. illudens* Peck and *Xerocomus griseoolivaceus* McNabb. The first is a fungus familiar to the senior author and widespread in mid-west America in open hardwood forests, especially under *Quercus* around low lying areas. However, it has overall pale colours especially the pores, which when mature are only weakly yellowish and it is slightly cyanescent. *Xerocomus griseoolivaceus* McNabb from New Zealand is obviously very similarly coloured to *B. pallidus*, but is easily distinguished by its distinctly smaller basidiospores (8.4–10.4(–11) × 3.9–4.5μm) (McNabb, 1968). The pileus in *X. griseoolivaceus* is greyish fawn to greyish with olivaceous tints as the epithet suggests and not blackish brown as in *B. rectus* (McNabb,

1968). However, *B. illudens* Peck, placed in *Xerocomus* by Singer (1975), is a dark-capped fungus; it is placed by Smith & Thiers (1971) in *Boletus* subsect. *Versicolores*. It differs markedly from *B. rectus* in that the pileipellis of *B. illudens* contains hyphae which are orange-brown in Melzer's reagent; furthermore the pileipellis is a trichodermium of inflated cells.

There is considerable confusion as to the placement of *B. pallidus*. Singer (1951) placed the taxon in *Boletus* s. str., in sect. *Calopodes* indicating it to be intermediate between this section and sect. *Appendiculati*. Smith & Thiers (1971) on the other hand placed *B. pallidus* with *B. pulverulentus* Opat. and *B. badius* Fries in *Boletus* sect. *Pseudoboleti* (=*Xerocomus* sect. *Pseudoboleti* Singer). Based on observations on material from mid-west America the present authors do not agree with this latter placement.

Examination also indicated that *Woods* 5 is neither related to *B. pallidus* nor to *Xerocomus griseoolivaceus*; the North American species does not have distinctly phylloporoid trama.

Boletus sylvestris Petch sensu Chiu in Mycologia 40: 218 (1948).
SARAWAK. 4th Division Baram District, Gunong Mulu National Park, near Lobang Angin on buried fruit of *Eleocarpus* (Eleocarpaceae: Malvales) on clay soil under entrance to large cave, '*Pileus* 25mm red-brown (cinnamon to rust-colour) margin extending beyond tubes. *Stipe* 40 × 3–4mm, bright yellow at apex, with fibrils, flushed red below', 2 iv 1978, *Coppins* 5061 (E).

Supporting microscopic data are:
Basidiospores 10–11 × 4.5–5.5μm, broadly subfusiform (prominently boletoid) with very distinct suprahilar plage, rather rich honey-yellow in ammonia and slightly thickened. *Basidia* 4-spored. *Cheilocystidia* cucurbitiform, hyaline or pale honey-colour in ammonia; *pleurocystidia* absent or not recovered. *Caulocystidia* a mixture at stipe-apex of fertile basidia and long dark honey-brown hyphae ⩽ 90 long × 7.5–9μm and vesiculose cells resembling those of the pileipellis. *Pileipellis* of inflated, thin-walled cells overlain by loose filamentous, irregularly branched and contorted hyphae. *Hymenophoral trama* phylloporoid.

This is a distinct taxon close to *Boletus sylvestris* Petch, originally described from Ceylon (Petch, 1922), and also *B. calvus* Corner from Bukit Timah in Singapore (Corner, 1972). Both of these named species are recorded by Corner (1972) from Singapore and the former also from Malaya. The present collection is very probably conspecific with material described by Chiu (1948) from Yunnan, China. It is characterized by its slender stipe, dull brown, glabrous pileus and small stature. Unfortunately *Coppins* 5061 is not sufficient to formally describe the species as a new taxon.

Appendix

A species of *Heimiella* from Berumpet (*Woods* 20) has previously been described (p. 412) and compared with *Austroboletus betula*, *Boletus punctisporus* and *Heimiella kinabaluensis*.

A. betula holds an ambiguous position in *Austroboletus* as it did in *Boletellus* where it was placed by Gilbert (1931). Singer (1986) also placed it in *Boletellus* (in sect. *Allospori* Singer) along with *B. alveolatus* (Heim & Perreau) Singer, but both of these boletes have different spore-morphology from the rest of the

section. In fact the ornamentation exhibited by these two species agrees with that of *Heimiella* sp. 2 (p. 412) and *Boletus punctisporus* Corner. A depression within the ornamentation is located at the basidiospore apex of *Heimiella* sp. 2 (Figs 11 & 12) and although some relationship might be sought with *Austroboletus subflavidus* the basidiospores in this species are subfusiform (= boletoid) and, unlike *A. betula,* lack apical differentiation (see Figs 13 & 14).

The spore-morphology and the olivaceous spore-print indicate that both *A. betula*, and *Boletus* subgenus *Punctispora* Corner, in which *Woods* 20 would be placed should be linked with *Heimiella*. The following new combinations are proposed.

Heimiella subgenus **Punctispora** (Corner) Watling, **comb. nov.**
Basionym: *Boletus* subgenus *Punctispora* Corner in Garden's Bull., Singapore 27: 8 (1974).
Type by original designation: *Boletus punctisporus* Corner in Garden's Bull., Singapore 27: 8 (1974).

Heimiella punctispora (Corner) Watling, **comb. nov.**
Basionym: *Boletus punctisporus* Corner in Garden's Bulletin, Singapore 27: 8 (1974).

Three other species in this subgenus are:

Heimiella betula (Schw.) Watling, **comb. nov.**
Basionym: *Boletus betula* Schw. in Schr. Naturf. Ges. Leipzig 1: 90 (182).
Syn.: *Boletellus betula* (Schw.) Gilbert, Les Bolets, 108 (1931).
Ceriomyces betula (Schw.) Murrill in Mycologia 1: 144 (1909).
Austroboletus betula (Schw.) Horak in Sydowia 33: 72 (1980); superfluous combination made by Pegler & Young in Trans. Brit. Mycol. Soc. 76: 133 (1981).
Boletus morganii Peck in Bull. Torrey Bot. Club 10: 73 (1883).

Heimiella alveolata (Heim & Perreau) Watling, **comb. nov.**
Basionym: *Porphyrellus alveolatus* Heim & Perreau in Bull. Soc. Mycol. France, 80: 88 (1964).
Syn.: *Boletellus alveolatus* (Heim & Perreau) Singer in Flora Neotropica 5: 24 (1970).
Austroboletus alveolatus (Heim & Perreau) Horak in Sydowia 33: 72 (1980).

Heimiella fruticicola (Berk.) Watling, **comb. nov.**
Basionym: *Boletus fruticicola* Berkeley in Hooker's J. Bot. 7: 574 (1848).
Syn.: *Austroboletus fruticicola* (Berk.) Horak in Sydowia 33: 76 (1980).

The opportunity is taken to also make the following new combination in subgenus *Heimiella.*

Heimiella ivoryi (Singer) Watling, **comb. nov.**
Basionym: *Boletellus ivoryi* Singer in Singer, Araujo & Ivory in Beih. Nova Hedw. 77: 163 (1983).

Watling & Gregory (1986) recorded *Heimiella* for the first time from Australia but by adding *Boletus fruticicola* Berk., described from Tasmania, to the genus the distribution is extended. It is extended still further to the New World by the addition of *Boletus betula* Schw., *Boletellus ivoryi* and *Porphyrellus alveolatus,* the last, despite its generic placement, neither has purple tinged basidiospores nor tubes. *Heimiella fruticicola* extends from Southern Queensland to Tasmania (Watling & Gregory), 1986) whereas *H. betula* is widespread in the southern and southeastern parts of North America. Coker & Beers (1943) record it from North and South Carolinas and Georgia, a collection in E (*Watling* A2138/C2556 legit H. Thiers) is from Alabama. Horak (1980a) in transferring this species to *Austroboletus* records it from Michigan, confirming Smith & Thiers' (1971) earlier prediction that it should occur there. It is generally found under *Quercus* (Prov. Oaxaca, 29 vii 1959, 1800m) and *H. ivoryi* from Belize.

These four taxa and the collection from Sarawak now draw *Austroboletus* and *Heimiella* closer together, although Pegler & Young (1981) would have the former genus in the Strobilomycetaceae, the latter genus in the Boletaceae, and *Boletellus* in the Xerocomaceae. They also placed *Boletus betula* in *Austroboletus* but remark that the spore-print is olivaceous, something on which the present authors place some significance. Indeed, Pegler & Young (1981) indicated that *B. betula* 'may have a closer relationship with Boletaceae than Strobilomycetaceae, so linking *Heimiella* with *Boletus*'. With this we agree!

Corner's discussion when erecting the subgenus *Punctispora* is relevant; also he drew attention to the similarities between *Boletus punctisporus* and *B. betula* something which is now formally expressed in the classification. Grand & Moore (1971) offered excellent scanning electron micrographs of *B. betula.* Watling & Gregory (1986: 101) emphasized that 'there are some similarities between *Austroboletus fruticicola* and *Heimiella*', although they retained the former under *Austroboletus* because of the pinkish pores. Based on a re-examination of the basidiospores of the Australian material a realignment was necessary.

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